

Original Article

A Simple Fight Decision Support System for BVR Air Combat Using Fuzzy Logic Algorithm

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Abstract: Beyond Visual Range (BVR) air combat is a future trend of war tactic. In this situation, a fighter can attack the opponent before direct encounter. Its complexity arises due to the necessity to take into account the information of target's maneuver, the specification of the missile, and the advantage of fighter position. In this paper, a simple BVR air combat system has been developed to give a fight strategy for pilot. Some important parameters are considered, such as the distance and the azimuth position of the target's as well as the range and the energy of missile to reach the target. The information is processed to determine the fighter supremacy and the opponent's threat factor. The result of the processing is used as an input of fuzzy logic algorithm to determine the optimal fighting strategy. The feasibility of the model and validity of the algorithm are verified by simulation under two typical situations.

Keywords: beyond visual range, air combat, fuzzy logic, fighting strategy

1. Introduction

The development of air combat tactic using artificial intelligence is important in modern air combat. In [1]-[3] the air combat situations are analysed to support the pilot in making a strategic maneuver. Artificial intelligence is used to make the pilot's decision.

This study uses fuzzy logic algorithm to determine the optimal strategy for pilot. The recommendation strategy consists of all-out attack, fight defensively, and run away. In [4], an important opponent movement information is needed for analysis. The opponent movement can be categorized as rear approaching, rear flanking, rear escaping, sides approaching, sides flanking, sides escaping, front approaching, front flanking, front escaping. This information is crucial for the pilot to reduce risk encounter the target which less probability he can win.

2. Methods

This study uses fuzzy logic to calculate the Beyond Visual Range (BVR) decision making parameters. The input is the opponent's position (latitude, longitude and altitude), opponent's speed and direction of crossing flight (velocity and heading) and opponent's supremacy which is a function of aircraft type, sensor and armament capabilities.

The method consists of three main process, namely aircraft identification, target intension judgment, and supremacy calculation. The aircraft identification gathers and analyses RCS data, which is combined with weaponry database to calculate the threat factor. The target intension judgment is calculated by analysing radar data including location, velocity vector, and impact angle.

The final step is calculating supremacy factor based on the threat and intension factor, as presented in Figure 1.

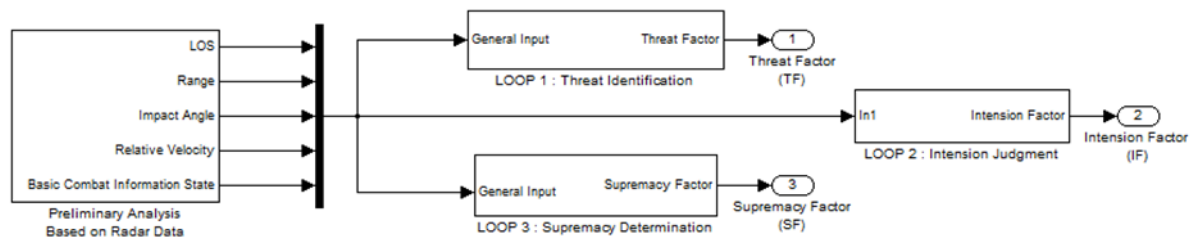


Figure 1. Fuzzy logic diagram of the target intention judgment

The supremacy factor is calculated by using supremacy function S , as given below

$$S = \alpha_p(\beta_d f_d + \beta_\varphi f_\varphi + \beta_\theta f_\theta) + \alpha_E f_E \quad (1)$$

Where

α_d is weight for the total position supremacy

α_E is weight for the total energy supremacy

β_d is weight for the distance supremacy

β_φ is weight for the azimuth supremacy

β_θ is weight for the impact angle supremacy

f_d is function for the distance supremacy

f_φ is function for the azimuth supremacy

f_θ is function for the impact angle supremacy

The same detail of the function can be found also in other literatures [2,3]. To make decision, the supremacy factor is combined with superiority factor. The Superiority factor depends on agility, flight performance, and weaponry of the aircraft. The detail of the superiority factor can be found in [4].

Supremacy and superiority factors have a role as the input of fuzzy logic algorithm to determine 3 decision, they are including:

1. All-out attack
2. Fight defensively
3. Run away



Rule as an input in fuzzy logic

1. if (supremacy factor is low and superiority factor is high) then fight defensively
2. if (supremacy factor is low and superiority factor is mid) then run away
3. if (supremacy factor is low and superiority factor is low) then run away
4. if (supremacy factor is medium and superiority factor is high) then all-out attack
5. if (supremacy factor is medium and superiority factor is medium) then fight defensively
6. if (supremacy factor is medium and superiority factor is low) then fight defensively
7. if (supremacy factor is high and superiority factor is high) then all-out attack
8. if (supremacy factor is high and superiority factor is medium) then all-out attack
9. if (supremacy factor is high and superiority factor is low) then all-out attack

3. Simulations

Two simulations are performed using X-Plane simulator to test the method effectiveness. One is the direct encounter situation, named as 'approaching', and the other is chasing situation, named as 'escaping'.

1. Approaching

In this simulation, the attacker  and the target  are approaching each other. The attacker has the advantage of higher altitude position than the target. It also has a higher (medium) superiority, as presented in Figure 2.

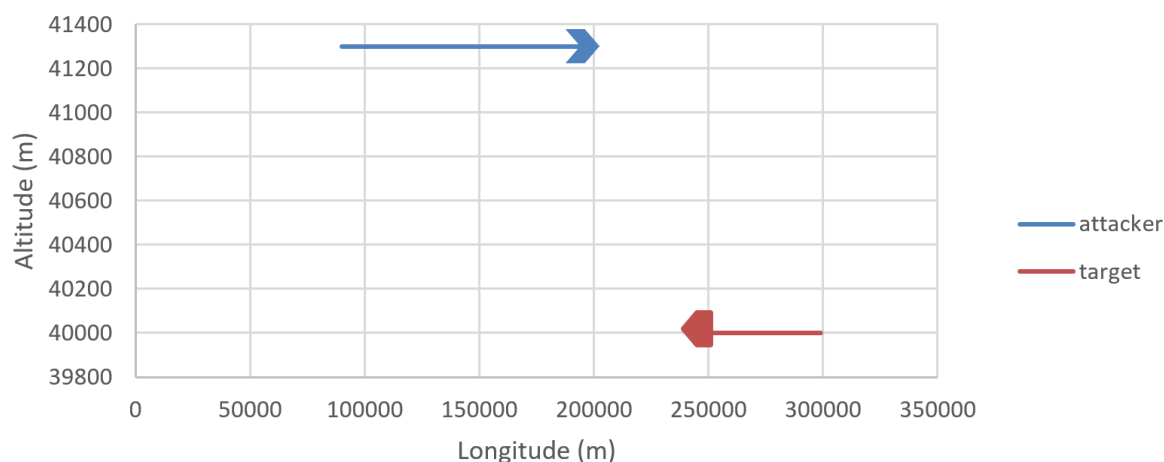


Figure 2. The attacker and the target approach each other

In Figure 3, the supremacy factor is increasing along with decreasing distance. It is because the target approach to the attacker's radar and missile detection area.

The decision strategy from fuzzy logic is shifting from fight defensively into all-out attack when the supremacy factor around 0.69 (from rule 5 to rule 8). In this case, the value of superiority factor is constant, but the supremacy factor is increased. This situation suggests the attacker to the attack target as presented in Figure 3.

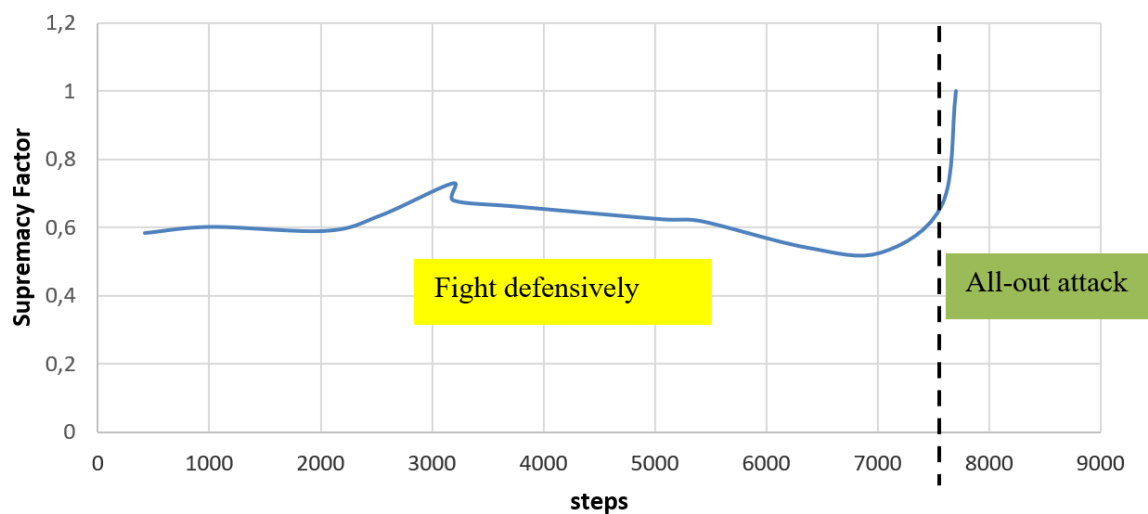




Figure 3. Supremacy factor for simulation when the attacker and the target approach each other

2. Escaping

In this simulation the attacker  pursuit the target  is approaching each other, refer to Figure 4. But the target can escape with higher velocity. The attacker has a higher (medium) superiority than the target.

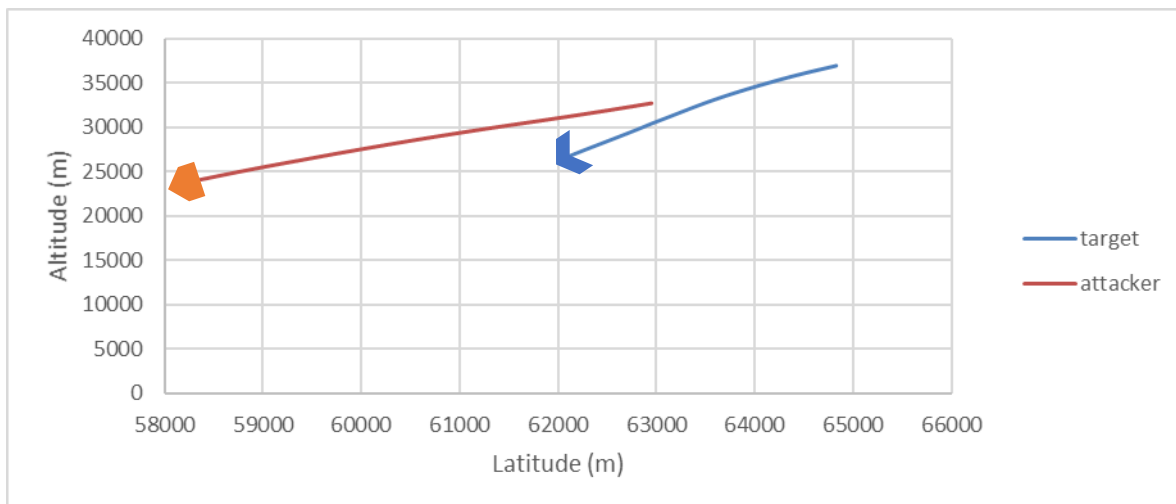


Figure 4. The attacker pursuit the target, but the target can escape with higher velocity

In Figure 5, the supremacy factor is decreasing along with increasing distance. It is because the target escape from the attacker's radar and missile detection area. The decision strategy from fuzzy logic is shifting from all-out attack into fight defensively when the supremacy factor around 0.7 (from rule 8 to rule 5). In this case, the value of superiority factor is constant but the supremacy factor is decreased to change the applied rule in fuzzy logic.

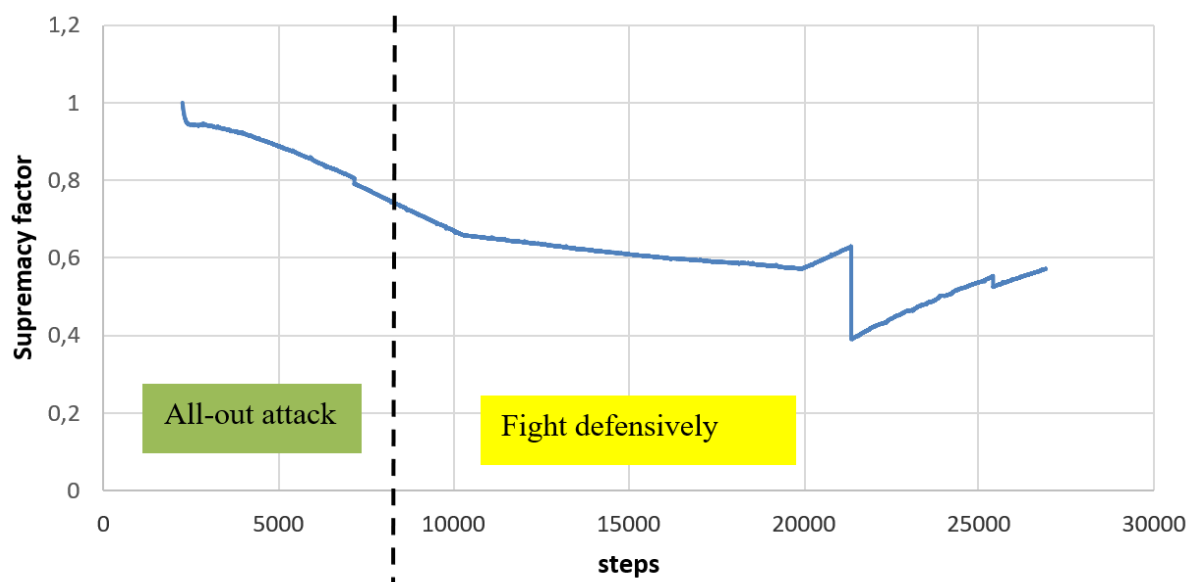


Figure 5. Supremacy factor for simulation when the target escape from the attacker

4. Conclusions

In this paper, automatic fight mode decision strategy in BVR air combat by using fuzzy logic algorithm was presented. Moreover, our method to automate strategy recommendation for BVR air combat has been proposed. The validity and verified information about the target are very important as an input in this method. In future work, the method will be extended to give recommendation for the maneuver strategy.

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